ALLIED
RELIABILITY AND
MAINTAINABILITY
PUBLICATION

ARMP-5

GUIDANCE ON RELIABILITY AND MAINTAINABILITY TRAINING

MAY 1988

NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION

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NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULGATION

MAY 1988

1. ARMP-5 "Guidance on Reliability and Maintainability Training" is a NATO UNCLASSIFIED publication. The agreement of interested nations to use this publication is recorded in STANAG 4174.

2. ARMP-5 is effective on receipt.

3. It is permissible to distribute copies of this publication to contractors and suppliers and such distribution is encouraged.

A.J. MELO CORREIA
Major-General, POAF
Chairman MAS

RECORD OF CHANGES

Change Date	Date entered	Effective Date	By whom Entered

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CHAPTER 1

INTRODUCTION

101. GENERAL

ARMP-1 (NATO Requirements for Reliability and Maintainability) is the baseline document for the achievement of the required levels of availability and mission success during the in-service life of military materiel. It emphasizes the need for properly conducted Reliability and Maintainability (R & M) work during the design and development stage.

The timely provision of military materiel with acceptable levels of R & M is essential to the achievement of the required operational effectiveness, coupled with acceptable life cycle costs. R & M requirements must be realistic and an agreed management strategy followed. This should include a continuous and evolutionary approach, with R & M as an integral part of any project, from inception to final acceptance into service. Special attention must be paid as to how R & M characteristics affect logistic expenditure - maintenance equipment installations, manpower and spares provisioning.

In order to raise the standards of R & M throughout NATO it is essential that the subject is properly understood and applied at all levels and during all phases of the procurement process. To this end, the need for adequate training is self-evident and this ARMP is intended to give guidance on this aspect.

102. SCOPE AND APPLICABILITY OF NATO R & M TRAINING

In the most simple terms, people who require training in the theory and practice of R & M are:

a. those who are full-time and specialized R & M practitioners, advisers or consultants

b. those whose work involves them in decisions or management processes concerned with R & M or brings them into contact with specialized R & M practitioners.

By its very nature, specialized R & M knowledge is normally only acquired by attendance at a second degree course or equivalent; such training will normally be conducted only by Universities or comparable Institutions. The definition of such training is not an appropriate subject for this publication and will not be considered further. It remains only to be said that, in the procurement of modern military equipment, the availability of specialized R & M advice at this level is regarded as essential. Suitably trained and qualified specialists must therefore be available and their advice sought at the earliest possible date.

This publication is addressed to the second category and it is emphasized that training at this level should cover the broadest possible field: purchasing and procurement staff concerned with the procurement of NATO materiel, contractors involved in design, development and production and also those responsible for NATO material in-service.

103. RELATED DOCUMENTS

ARMP-1	NATO Requirements for Reliability and Maintainability
ARMP-2	General Application Guidance on the Use of ARMP-1
ARMP-3	Application of National R & M Documents
ARMP-4	Guidance for Writing NATO R & M Requirement Documents
ARMP-6	In-Service R & M

CHAPTER 2

R & M TRAINING COURSES

201. GENERAL

For obvious and practical reasons, it is not possible to cover all the areas and levels, below that of the full-time specialist, for which R & M training is appropriate. Practical experience has shown that there are, in fact, two levels for which training is both extremely important and feasible.

202. TRAINING FOR SENIOR MANAGERS AND ENGINEERS

Senior staff, both in government procurement agencies and industry, should be aware of the need for comprehensive R & M programmes during development but require only a broad over-view of the subject. Any project management training course should include appropriate coverage of R & M. This may not in itself be sufficient and it is recommended that one-day seminars on R & M are organized in order to guarantee the widespread dissemination of the fundamentals of R & M at this level.

An example seminar syllabus is at Annex A. It should be noted that seminars of such short duration need not be confined to a centralized training location but can be taken to the recipients, thus making it easier for senior staff to attend.

203. TRAINING FOR MIDDLE LEVEL MANAGERS AND ENGINEERS

At the middle levels of management and engineering, staff are in more immediate and regular contact with R & M programmes and require a more detailed knowledge of the subject. At this level, a one week course is suggested. A possible outline syllabus is at Annex B. Such courses are best conducted at residential training centres where maximum use can be made of the available time and opportunities exist for practical work and syndicate discussion. The list of topics should not be regarded as exhaustive; variations may well have to be made to suit the broad classes of equipment being covered or the available instructional talent. The value and importance of including selected real-life examples in such training is emphasized.

ANNEX A to
ARMP-5

SYLLABUS FOR A SENIOR STAFF SEMINAR ON THE ACHIEVEMENT OF NATO R & M REQUIREMENTS

	SESSION	TOPICS	APPROX TIME (Mins)
1.	INTRODUCTION	Aims of the Seminar - organization of sessions - structure and role of NATO ARMPs	15
2.	TERMINOLOGY AND MAIN CONCEPTS	Definition of R & M terms - organization of resources - maintenance concept - tailoring concept. Importance of R & M to enhanced operational effectiveness and reduced through-life costs.	30
3.	SPECIFICATION	Specification of R & M Requirements	40
4.	GENERAL REQUIREMENTS	R & M programme - engineering requirements - traceability - interfaces and co-ordination - quantitative requirements - documentation	60
5.	TASKS	Scope of tasks - management of tasks - importance of design - trade-off studies - testing - reliability growth - monitoring sub-contractors and suppliers - feedback during production cycle - influence of software	80
6.	IN-SERVICE R & M	Data collection - monitoring achievement - corrective action	30
7.	SIMPLE CASE STUDIES	Examples of typical R & M successes and failures	60
8.	CONCLUSION	Summary and general discussion	45
		Total time	360

how [UU] will implement commercial, international, national, federal, or military standards within the functional profile

SYLLABUS FOR A 5-DAY COURSE FOR MIDDLE MANAGEMENT ON THE ACHIEVEMENT OF NATO R & M REQUIREMENTS

LECTURE NO	TOPICS	APPROX TIME (Mins)
Day 1		
1	INTRODUCTION - Self introduction by Course staff and Course members - Course administration - purpose and structure of Course - organization of sessions	15
2.	OVERALL REQUIREMENTS - Importance of R & M - need for common policy within NATO - development of ARMPs - contractual status of ARMPs - use in collaborative projects - tailoring concept	20
3.	TERMINOLOGY - Basic definitions of availability, reliability and maintainability - meaning of purchaser and contractor - failure and repair definitions - failure rates and repair time distributions - critical and life-limited items - discrepancies - life and mission profiles	20
4.	FAILURE CAUSES - Failures due to design stresses, due to manufacturing defects, due to maintenance and mal-operation - early life, random and wear-out failures - modes of operation and levels of failure	20
5.	ORGANIZATION FOR R & M - Need for effective organization for R & M - role of purchaser and contractor - R & M in the procurement cycle - organization of resources - the maintenance concept - trade-off with cost and performance - in-Service R & M organization	40
6.	SPECIFICATION FOR R & M - Staff targets and requirements - methods of specifying R & M requirements (Quantitative and Qualitative) - relationship to maintenance concept - translation of requirements into contractural specifications - incentive clauses and warranties	40
7.	R & M PROGRAMME - Establishment of R & M programme - role of purchaser and contractor - R & M programme plans - programme implementation and monitoring - influence of reliability and maintainability on the design phase - R & M in development and production - interfaces and co-ordination - programme documentation - need for traceability	60

8.	CASE STUDY - For a typical defence project examine and discuss the specifications, contracts and programme plan to meet the R & M requirements	60
9.	SYNDICATE EXERCISE - Briefing on exercise to be undertaken by the students in syndicates during the course - suggested topic: to write or review a R & M programme plan for a typical Defence project	20
	Total Time	295

Day 2

10	ENVIRONMENTAL CONDITIONS - determining duty cycles - environmental conditions experienced - other factors, e.g. manufacturing, storage	20
11	ALLOCATIONS - allocation and apportionment of R & M requirements	15
12	RELIABILITY PREDICTION - Similar equipment, similar function, parts count, parts stress analysis - MIL Handbook 217D and relevant computer programs - manual exercise and demonstration of computer analysis (if possible) - example of prediction - reliability apportionment	90
13	MAINTAINABILITY PREDICTION - Application, downtime, skill levels, logistics policy, MIL Handbook 472 - reliability centred maintenance - maintenance engineering analysis - integration of maintainability data with logistic support	40
14	R & M MODELLING - Reliability models - system dependencies - reliability block diagrams - analytical and simulation models - Markov analysis - Monte Carlo simulation - maintainability models - evaluation of intended level of repair - requirements for updating models	60
15	FAILURE MODES EFFECTS AND CRITICALITY ANALYSIS - Purpose of failure modes effects analysis (FMEA) - application - procedure - functional and hardware approaches - criticality analysis - relationship to FMECA - MIL Standard 1629A - examples	60

16	FAULT TREE ANALYSIS - Application - symbols - construction - top/event fault - common mode failures - minimum cut sets - examples	60
	Total Time	345

Day 3

17	R & M DESIGN CRITERIA - Importance of R & M in design - contractors' role - reliability design criteria - reliability design guidelines - maintainability design criteria - diagnostic strategy - maintainability design guidelines - design criteria for human functions - updating requirements - sneak circuit analysis	60
18	SOFTWARE R & M - Contribution of software to system R & M - software development strategies - test programs - verification and validation - support technology and tools - software problems	60
19	DESIGN REVIEWS - Need for formal design reviews - frequency - attendance - content - check lists - presentation - case studies	40
20	ENVIRONMENTAL STRESS SCREENING - Purpose of environmental stress screening (ESS) - ESS application - methods and techniques - ESS test plan - analysis of results and corrective actions	30
21	RELIABILITY GROWTH - Test, analyse and fix principle - growth planning - monitoring - theoretical models - contractual aspects - reliability development/growth test (RDGT) plan - case studies	90
22	R & M Qualification Test Programme - Purpose of programme - reliability qualification test (RQT) - RQT plan - maintainability qualification test (MQT) - MQT plan - criteria of compliance - cost factors - integration with overall qualification testing plan	60
23	PRODUCTION RELIABILITY ACCEPTANCE TEST (PRAT) PROGRAMME - Purpose - criteria of compliance - cash limits - PRAT plan	20
	Total Time	360

Day 4

24	TRADE-OFF STUDIES - Purpose of trade-off studies - frequency - parameters considered	15
25	CRITICAL AND LIFE-LIMITED ITEMS - Importance of critical items - identification and listing - control and special handling - life-limited items - avoidance of use - factors limiting item lives - determination of item lives - monitoring of critical life-limited items - input to maintenance requirements	90
26	INTEGRATION OF PURCHASER-SUPPLIED EQUIPMENT - R & M characteristics of purchaser-supplied equipment (PSE) - provision of information by purchaser - need for evaluation and validation of R & M information for PSE - co-operation between purchaser and contractor	20
27	MONITOR/CONTROL OF SUB-CONTRACTORS AND SUPPLIERS - Monitoring/control of sub-contractors and suppliers R & M programmes	15
28	FAILURE DATA REPORTING ANALYSIS AND CORRECTIVE ACTION SYSTEM - Closed loop data reporting during development and testing - early corrective action, failure definition, failure causes, failure mechanisms - relationship to design reviews - need for data accuracy	30
29	IN-SERVICE R & M - R & M assessment plans - data collection on early in-service systems/equipment - relation with Purchaser's maintenance organization - corrective actions based on failure causes - maintenance data centres - use of in-service data in specifications	30
30	CASE STUDY - Based on a typical defence project and requiring trade-off studies and the management of critical and life-limited items	60
31	SYNDICATE EXERCISE - Continuation of syndicate work	90
	Total Time	350

Day 5

32	SYNDICATE EXERCISE PRESENTATIONS - Presentations and discussion by syndicates of results of course exercise	180

33	COURSE SUMMARY - Review of topics covered and questions raised by students	30
34	COURSE APPRAISAL	20
	Total Time	230